11 Facility Guidelines

These facility guidelines are intended to guide development of all types of bikeway facilities. The first section considers the necessary planning aspects of bikeway system design in general. The following section discusses general physical design guidelines. Subsequent sections provide physical design information for specific classes of bikeway facilities.

11.1 Bikeway Planning

Successfully implementing a bikeway system involves careful planning that considers a number of issues, including setting up appropriate mechanisms to take advantage of bikeway opportunities as they become available. Author and bicycle planning expert Susan Pinsof has perhaps described the process most succinctly:

"A comprehensive, affordable approach to bicycle planning involves maximizing the usefulness of existing infrastructure by improving the safety of shared roadway space; using opportunities, such as available open space corridors for trails; creating more "bicycle-friendly" communities through planning, design and regulation; and addressing the need for bicycle safety education and encouragement."

11.1.1 Local Emphasis

Cycling is primarily a local activity since most trips do not exceed five miles. Experienced cyclists routinely ride further than this and their cross-community travel should be accommodated. However, if it is a community goal to make localized cycling a viable option for personal transportation, then cyclist mobility must be improved and enhanced throughout the community, especially to important local destinations. Even though State or Federal policies may influence or even dictate some design and implementation decisions, it is local decisions that will most significantly affect the potential for cycling within a community.

11.1.2 Master Plan Process

The basis for a bicycle-friendly community can be established by instituting appropriate policies through the development and adoption of this bicycle master plan. A program of physical improvements and workable implementation strategies that reflects local needs was developed as part of this master plan. A bicycle master plan will be of little value if it is not part of an active and ongoing planning process that continually seeks to integrate cycling considerations into all areas of local planning.

Within this master plan, facility design guidelines have been tailored to local conditions, but are also consistent with national guidelines, such as the AASHTO Guide to Development of Bicycle Facilities. State guidelines are also referenced, specifically, Caltrans Highway Design Manual, Chapter 1000, Bikeway Planning and Design and the Caltrans Traffic Manual. Elements of these guidelines without relevance to the region have been excluded.

11.1.3 "Institutionalizing" Bicycle Planning

Achieving implementation of this master plan will be greatly expedited by "institutionalizing" bicycle planning, a concept first developed by Peter Lagerway of the city of Seattle, Washington as part of his efforts as the city's pedestrian and bicycle coordinator. The term refers to coordinating local planning and regulatory functions in the development of a program of improvements. The three elements needed to institutionalize bicycle planning on a local level are a bicycle advisory committee, a bicycle coordinator and committed public officials.

Bicycle Advisory Committee

Public involvement can be promoted through the formation of a bicycle advisory committee as a new city committee, or as a subcommittee of an appropriate existing committee. Its primary benefit would be in providing an avenue for public participation and support.

Bicycle Coordinator

City government involvement can occur through the designation of a bicycle coordinator. For a city the size of Chula Vista, this may be a part-time position, but this does not diminish its importance. Since a truly comprehensive bicycle planning effort will involve many city departments including public works, parks and recreation, planning, schools and police, the bicycle coordinator would be in a position to organize interdepartmental efforts and make certain that bicycle concerns are integrated into other city activities in the planning stages, as well as coordinate with adjacent communities and jurisdictions.

Public Officials
The third aspect of institutionalization of bicycle planning involves obtaining the commitment of public officials. Leadership for bicycle improvements may already come from public officials, but even if it does not, officials will be more likely to be supportive if they can be certain their constituency wants a more bicycle-friendly community.

11.1.4 Primary Planning Considerations
The safety, efficiency and enjoyment of the bike facility by expected users should be the primary considerations employed in the planning of new bicycle facilities. More specifically, such considerations should include the following:

• Direct and convenient alignment to serve trip origins and destinations;
• Access to and from existing and planned bicycle facilities;
• Avoiding abrupt facility discontinuity;
• Avoiding steep grades whenever possible;
• Adequate lighting and sight lines;
• Convenient bicycle parking at destinations;
• Adequate commitment to maintenance.

11.1.5 Integration with Other City Plans and Programs
Bikeway facility planning requires a high level of coordination because it is directly affected by the planning decisions of other City departments, as well as those of adjacent communities, the county, regional and state agencies. Land use, zoning, street design, open space and park planning all affect how bicycle-friendly a community can be. For examples, land use patterns affect cycling by determining the locations of trip origins and destinations by such means as creating areas of employment and housing densities sufficient to sustain bicycle facilities, or by providing a balance of housing and jobs by encouraging multi-use development. Access or bicycle parking facilities can often be included in developments at a low cost. Also, the provision of better access and connections between developments for cyclists and pedestrians may be more easily provided if the need is understood and articulated as early as possible in the planning process.

Effective bicycle planning requires review of regional transportation plans, local street plans, park and open space plans and even site plan review. Transportation plans provide opportunities for low cost improvements to be designed into subsequent projects. Local street plans provide opportunities to implement changes that make streets more conducive to cycling using techniques such as “traffic calming” (Section 11.2.22). Park and open space planning provide opportunities to acquire greenways and to build multi-use trails. Site plan review provides opportunities to ensure that project design accommodates cyclists through the provision of improvements such as access or parking facilities and that the project’s vehicular traffic does not decrease the safety of cyclists of adjacent facilities.

11.1.6 Education and Encouragement
Education and encouragement of cycling are important elements of any bicycle planning effort and can occur through instructional venues such as school curricula and through the efforts of large employer-based transportation programs. There is no shortage of educational materials available through a number of private and government organizations. The dissemination of meaningful information can also be augmented by the participation of local businesses such as bike shops, especially since they have a vested interest in promoting safe cycling in Chula Vista. Education and encouragement rarely receive the attention they deserve even when included in bikeway master plans and this is where a bicycle coordinator can be of help in developing appropriate programs.

11.1.7 Regulating Land Use and Community Design to Benefit Cycling

Land use and design options are largely determined by regulatory functions that, in turn, help to define community character and functionality. These regulatory functions such as subdivision regulations, zoning requirements and developer exactions are also often used to set requirements for amenities in new development projects. These same regulations can be used to help define development patterns more conducive to cycling such as incorporating more mixed use, higher densities and connections between communities and land uses. Street patterns and hierarchy can greatly affect average daily (motor vehicle) trips (ADTs), connectivity and motor vehicle speeds, which in turn positively or negatively affects cycling. Street design can be modified to discourage high motor vehicle speeds and to provide width for a bike lane. Linear open space can become land for greenway routes that benefit all non-motorized users, not just cyclists.

Though prioritization of bikeway projects is defined by State and local decisions, it is Federal funding and policies that currently encourage the use of transportation funds for bicycle and pedestrian projects. However, Federal funding cannot be counted upon as a reliable source for the foreseeable future since it depends on the political nature of legislative action. Bicycle planning cannot sustain itself on the occasional Federal grant. Future local implementation will more likely depend on instituting bicycle improvements as part of infrastructural projects, which is when they are most cost-effective.

Similarly, the most economical way to include bicycle facilities in private development is through initial project planning and design, not as an afterthought. Ordinances can be written that bikeway systems be included as part of new developments. An effort should be made to show developers that such requirements are worthwhile because they create well established marketing advantages gained from providing pedestrian and bicycle amenities. Ordinances can also require bicycle amenities such as bicycle parking, showers and lockers at employment sites. In all cases, a bicycle master plan is important for establishing priorities for such public/private projects.

Review of developments for transportation impacts should address how on-site bicycle facilities are planned. Bicycle storage racks should be provided at commercial facilities at locations convenient to building entrances and covered from the elements. This is especially important at retail and service establishments. At employment sites, secure bicycle racks and/or lockers should be provided.

Requiring developments near commuter rail stations to provide access pathways to these transit centers as part of urban in-fill may improve multi-modal connections for pedestrians and cyclists alike. Other developers should contribute to bicycle master plan implementation projects in newly developing areas. Park land dedication or fees in lieu of dedication is another possible component of strategies to acquire local trail and bicycle path rights-of-way.

11.1.8 Bicycle Parking Facilities

The selection and placement of bicycle racks is an important issue because the lack of secure parking keeps many people from using their bikes for basic transportation. Leaving a bicycle unattended, even for short periods, can easily result in damage or theft. Finding a bike rack that does not work or is not conveniently located is a frustrating experience.

Many of Chula Vista's larger employers provide bicycle parking facilities, but they are intended for employee use. Like typical American municipalities, public bicycle parking is not widely available and no real facility inventory is available. The City of Chula Vista does not currently have a bicycle parking policy, but one is recommended. The

City should encourage the use of alternate forms of transportation by requiring the provision of bike racks and shower facilities for employers with greater than a specified number of employees.

To help achieve parity with drivers, the City could also require bicycle parking as a condition of all new development where motor vehicle parking is also required and develop a program to provide bike racks in existing commercial areas. These programs should include bike rack design and installation standards such as those in the following section.

The following paragraphs focus on outdoor installations using racks intended to accommodate conventional, upright, single-rider bicycles and the use a solid, U-shaped lock, or a cable lock, or both.

Rack Element
The rack element is the part of the bike rack that supports one bicycle.

It should support the bicycle by its frame in two places, prevent the bicycle wheel from tipping over, allow the frame and one or both wheels to be secured and support bicycles with unconventional frames. The rack element should also resist being cut or detached using common hand tools, especially those that can be concealed in a backpack. Such tools include bolt cutters, pipe cutters, wrenches and pry bars.

Rack
The rack itself is one or more rack elements joined on a common base or arranged in a regular array and fastened to a common mounting surface.

The rack elements may be attached to a single frame or remain single elements mounted in close proximity. They should not be easily detachable from the rack frame or easily removed from the mounting surface. The rack should be anchored so that it cannot be stolen with the bikes attached such as with vandal-resistant fasteners.

The rack should provide easy, independent bike access. Typical inverted “U” rack elements mounted in a row should be placed on 30” centers. Normally, the handlebar and seat heights will allow two bicycles to line up side-by-side in opposite directions. If it is too inconvenient and time-consuming to squeeze the bikes into the space and attach a lock, cyclists will look for an alternative place to park or use one rack element per bike and reduce the projected parking capacity by half.

Rack Area
The rack area is a bicycle parking lot where racks are separated by aisles.

A rack area or “bicycle parking lot” is an area where more than one rack is installed separated by aisles measured from tip to tip of bike tires across the space between racks. The minimum separation between aisles should be 48 inches, which provides enough space for one person to walk one bike. In high traffic areas where many users park or retrieve bikes at the same time, such as at colleges, the recommended minimum aisle width is 72 inches The depth for each row of parked bicycles should also be 72 inches.

Large rack areas in high turnover areas should have more than one entrance. If possible, the rack area should be protected from the elements. Even though cyclists are exposed to sun, rain and snow while en route, covering the rack area keeps the cyclist more comfortable while parking, locking the bike and loading or unloading cargo. A covering will also help keep the bicycle dry, especially the saddle.

Rack Area Site

The rack area site is the relationship of a rack area to the building entrance and approaches.

Rack area location in relationship to the building it serves is very important. The best location is immediately adjacent to the entrance it serves, but racks should not be placed where they can block the entrance or inhibit pedestrian flow. The rack area should be located along a major building approach line and clearly visible from the approach.

The rack area should be no more than a 30-second walk (120 feet) from the entrance it serves and should preferably be within 50 feet. A rack area should be as close or closer than the nearest car parking space, be clearly visible from the entrance it serves and be near each actively used entrance. Racks far from the entrance or perceived to be vulnerable to vandalism will not be used by most cyclists.

In general, smaller, conveniently located rack areas should serve multiple buildings, rather than a larger combined, distant one. Racks far from the entrance or perceived to be vulnerable to vandalism will not get much use.

Creative Design

There are many creative, three-dimensional bicycle parking racks that work very well. Creative designs should carefully balance form with function. Whatever the rack configuration, the critical issue is that the rack element supports the bike in two places and allows the bicycle to be securely locked. All racks must be carefully manufactured and maintained to prevent weaknesses at the joints that might compromise bicycle security.

11.1.9 Locating Bicycle Facilities on Roadways

The appropriateness of a roadway facility for bicycling is influenced by a number of factors. These factors can generally be classified into the following categories:

Land Use and Location Factors

These factors represent the most significant category affecting compatibility. Since bicycle trips are generally shorter than motor vehicle or mass transit trips, there must be a manageable distance between origins and destinations, such as between residential areas and places of employment. There are certain key land uses, which are especially likely to generate bicycle traffic if good bicycle facilities are available. These consist of, but are not limited to, transit centers, schools, employment centers with nearby residential areas, recreation areas and mixed use areas.

Physical Constraint Factors

These consist of roadway geometric or physical obstacles to bicycling, which are difficult or costly to remedy. For example, a roadway may be appropriate because of location factors, but not appropriate because of the existence of physical constraints to bicycling such as a narrow bridge, insufficient right-of-way or intersections with restricted lane widths resulting from lane channelization. The feasibility of correcting these physical constraints must be weighed in designating bikeways.

Traffic Operations Factors

These include traffic volume, speed, the number of curb cuts or conflict points along the roadway, sight distance and bicycle-sensitive traffic control devices. Experienced cyclists will use roadways even if they have limiting traffic operational factors, but less confident cyclists will perceive such roadways as unsafe and intimidating. These roadway facilities should be designed or improved to accommodate cyclists through the shared use of roadways. However, they are inappropriate for full designation as bikeways.

Other safety issues such as maintenance and pavement repair are also important considerations in the designation of bikeways, but do not directly affect the planning aspects of appropriate facilities.

11.1.10 Integrating Bicycle Facilities into the Roadway Planning Process

Planning for bicycle facilities on roadways should begin at the very earliest stage of project development on all sizes and types of roadway projects. Even the smallest roadway reconstruction project could result in a missed opportunity if cyclists are not taken into consideration at the initiation of the project. At the municipal level, planners should address these roadway planning issues in the comprehensive context of the circulation element in the municipal master plan.

The following procedure offers the planner and designer guidance in determining the need for bikeways during the usual phases of project development.

Needs Assessment

The first step in the planning process for any transportation project is the assessment of needs. Existing and planned land use, current and projected traffic levels and the special needs of the area population are examined. There are circumstances in which a portion of the transportation need might be served by non-motorized means, as well as locations where existing bicycle demand would be better served by improved facilities. The following land use and location factors assist in recognizing the potential for non-motorized travel and evaluating the needs of cyclists at the street level.

The roadway:

- Serves an activity center, which could generate bicycle trips;
- Is included on a county or municipal bicycle master plan;
- Provides continuity with or between existing bicycle facilities, including those of adjacent cities;
- Is located on a roadway, which is part of a mapped bike route or utilized regularly by local bicycle clubs;
- Passes within two miles of a transit center;
- Passes within two miles of a high school or college.
- Passes within a half mile of an elementary school or middle school;
- Passes through an employment center, especially if there is a significant residential area within a three mile radius; or
- Provides access to a recreation area or otherwise serves a recreation purpose.

If any one of these factors exists, the roadway has the potential to attract less experienced bicycle riders and/or significant numbers of advanced riders. As a result, it should be considered as potentially appropriate for designation as a bikeway.

The planner should include a description of the potential significance of the roadway as a bikeway facility in the project initiation or scoping document that will be forwarded to the project designer. If the planner determines that the project is potentially appropriate for designation as a bikeway, the nature of potential bicycle use should be addressed, including factors affecting roadway design, such as roadway truck volumes or intersections.

Preliminary Engineering

Roadway facilities that have been determined through needs assessment to be potentially appropriate for bikeways should be analyzed to determine whether any physical constraints exist that may limit the facility type that could be provided. The following factors should be considered:

• Sufficient right-of-way exists, or additional right-of-way can be acquired to allocate the required space for a bikeway;
• Physical impediments or restrictions exist, but they can be avoided or removed to allow for the required pavement width to provide a bikeway;
• Bridges allow for bicycle access in accordance with bikeway standards; and
• Travel or parking lanes can be reduced in width or eliminated to allow space for bikeways.

If these factors occur, a bikeway should be recommended at the completion of the preliminary engineering phase for the following situations:

• Transportation facilities or segments that connect bicycle traffic generators within five miles of each other; or
• Segments of transportation facilities that provide continuity with existing bicycle facilities.

If physical constraint factors that preclude allocation of space and designation of bikeways exist along a particular roadway and cannot be avoided or remedied, these factors should be reported to the project manager in the final design phase and alternative design treatments should be generated.

Planning and engineering should consider more than roadway cross-sections. Often, the most difficult potential areas of conflict are at intersections. In general, high speed interchanges, merge lanes and wide radius curbs are unsafe for cyclists and should be avoided.

Final Design And Facility Selection
Class 2 facilities are usually more suitable in urban settings on roads with high traffic volumes and speeds. Class 3 facilities are often used in urban settings to guide cyclists along alternate or parallel routes that avoid major obstacles, or have more desirable traffic operational factors.

In rural settings, Class 2 facilities are not usually necessary to designate preferential use. On higher volume roadways, wide shoulders offer cyclists a safe and comfortable riding area. On low volume roadways, most cyclists prefer the appearance of a narrow, low speed country road.

Table 11-1 recommends the type of bikeway and pavement width for various traffic conditions. For locations where pavement widths do not meet the criteria listed in the table, the local municipal bicycle authority should be consulted to assist in the decision-making process.

Where physical obstructions exist that can be removed in the future, the roadway facility should be designed to meet bikeway space allocation requirements and upgraded and designated when the physical constraint is remedied (i.e., bridge is replaced and improved to allow designated facility).

The final design should be coordinated with the bicycle coordinator for review and approval prior to construction.

When the needs assessment and preliminary design indicate the need for bikeways, the designer should consider traffic operations factors in determining the actual design treatment for the bikeway. The following should be considered in the design of the roadway and bicycle facility:

• Existing and projected traffic volumes and speeds;
• Existence of parking (Can parking be restricted or removed to allow better sight distances?);

• Excessive intersection-conflict points (Can intersection-conflict points be reduced along roadways?);
• Turn lanes at intersections that can be designed to allow space for cyclists;
• Sections with insufficient sight distance or roadway geometrics be changed; or
• Traffic operations be changed or "calmed" to allow space and increased safety for cyclists.

11.2 General Physical Guidelines

The following sections cover physical design guidelines applicable to all bikeway facility types. Guidelines specific to Class 1, 2 and 3 facilities are covered in subsequent sections.

11.2.1 Pavement Width
At a minimum, all roadway projects shall provide sufficient width of smoothly paved surface to permit the shared use of the roadway by bicycles and motor vehicles.

Table 11-1 is based on the FHWA publication, Selecting Roadway Design Treatments to Accommodate Bicycles. Pavement widths represent minimum design treatments for accommodating bicycle traffic. These widths are based on providing sufficient pavement for shared use by bicycle and motor vehicle traffic and should be used on roadway projects as minimum guidelines for bicycle compatible roads.

Considerations in the selection of pavement width include traffic volume, speed, sight distance, number of large vehicles (such as trucks) and grade. The dimensions given in Table 11-1 for shared lanes are exclusive of the added width for parking, which is assumed to be eight feet. On shared lanes with parking, the lane width can be reduced if parking occurs only intermittently. On travel lanes where curbs are present, an additional one foot is necessary.

On very low volume roadways with ADTs of less than 1,200, even relatively high speed roads pose little risk for cyclists since there will be high probability that an overtaking motor vehicle will be able to widely pass a bicycle. When an overtaking car is unable to immediately pass a bicycle, only a small delay for the motorist is likely. Both cyclists and motorists jointly use these types of roadways in a safe manner and widening of these roads is not usually recommended. Costs of providing widening of these roads can seldom be justified based on either capacity or safety.

Similarly, moderately low volume roadways with ADTs between 1,200 and 2,000 generally are compatible for bicycle use and will have little need for widening. However, since there is a greater chance of two opposing cars meeting at the same time as they must pass a cyclist, providing some room at the outside of the outer travel lane is desirable on faster speed roadways. On low speed roadways, motorists should be willing to accept some minimal delay.

With ADTs from 2,000 to 10,000, the probability becomes substantially greater that a vehicle overtaking a bicycle may also meet another oncoming vehicle. As a result, on these roads, some room at the edge of the roadway should be provided for cyclists. This additional width should be two to three feet added to a typical 11-foot outer travel lane. At low speeds, such as below 25 m.p.h., little separation is needed for both a cyclist and a motorist to feel comfortable during a passing maneuver. With higher speeds, more room is needed.

Recommended Pavement Widths* Table11-1

Posted Speed Limit	Urban w/ Parking	Urban w/o Parking	Rural
1,200 to 2,000 ADTs			
<30 mph	12 ft. SL	11 ft. SL	10 ft. SL
31-40 mph	14 ft. SL	14 ft. SL	12 ft. SL
41-50 mph	15 ft. SL	15 ft. SL	3 ft. SH
>50 mph	NA	4 ft. SH	4 ft. SH
2,000 to 10,000 ADTs			
<30 mph	14 ft. SL	12 ft. SL	12 ft. SL
31-40 mph	14 ft. SL	14 ft. SL	3 ft. SH
41-50 mph	15 ft. SL	15 ft. SL	4 ft. SH
>50 mph	NA	6 ft. SH	6 ft. SH
More than 10,000 ADTs or Trucks over 5%			
<30 mph	14 ft. SL	14 ft. SL	14 ft. SL
31-40 mph	14 ft. SL	4 ft. SH	4 ft. SH
41-50 mph	15 ft. SL	6 ft. SH	6 ft. SH
>50 mph	NA	6 ft. SH	6 ft. SH

Notes:

*Primarily applicable to Class 3 and "Undesignated" routes.

SH = Shoulder SL = Shared Lane

Shared lane is acceptable for volumes less than 1,200 ADTs.

Provide 8' shoulder for volumes greater than 10,000 ADTs.

At volumes greater than 10,000 ADTs, vehicle traffic in the curb lane becomes almost continuous, especially during peak periods. As a result, cyclists on these roadways require separate space to safely ride, such as a Class 2 facility. In addition, improvements to the roadway edge and the shoulder area will be valuable for motorists as well.

Caltrans guidelines for highways recommend that a full eight-foot paved shoulder be provided for State highways. On highways having ADTs greater than 20,000 vehicles per day, or on which more than five percent of the traffic volume consists of trucks, every effort should be made to provide such a shoulder for the benefit of cyclists, to enhance the safety of motor vehicle movements and to provide "break down" space, as well as a Class 2 facility. Otherwise, the highway should probably not be designated as a bicycle facility.

11.2.2 Sight Distance

Roadways with adequate sight distance will allow a motorist to see, recognize, decide on the proper maneuver and initiate actions to avoid a cyclist. Adequate decision sight distance is most important on high speed highways and narrow roadways where a motorist would have to maneuver out of the travel lane to pass a cyclist.

The pavement widths given in Table 11-1 are based on the assumption that adequate sight distance is available. In situations where there is not adequate sight distance, the provision of additional width may be necessary.

11.2.3 Truck Traffic

Roadways with high volumes of trucks and large vehicles, such as recreational vehicles, need additional space to minimize cyclist/motorist conflicts on roadways. Additional width will allow overtaking of cyclists by trucks with less maneuvering. Additionally, overtaking by a truck will exert less lateral force from truck drafts and provide greater sight distance for following vehicles.

Although there is no established threshold, additional space should be considered when truck volumes exceed five percent of the traffic mix, or on roadways that serve campgrounds, or where a high level of tourist travel is expected using large recreational vehicles. Where truck volumes exceed 15 percent of the total traffic mix, widths shown on the table should be increased by one foot minimum.

11.2.4 Steep Grades

Steep grades influence overtaking of cyclists by motorists. Cyclists climbing steep grades are often unsteady (wobbly) and may need additional width. Also, the difference in speed between a slow, climbing cyclist and a motor vehicle results in less time for the driver to react and maneuver around a cyclist. The slowing of a motor vehicle on a steep grade to pass a cyclist can result in a diminished level of service.

11.2.5 Unavoidable Obstacles

Short segments of roadways with multiple unavoidable obstacles that result in inadequate roadway width are acceptable on bicycle compatible roadways if mitigated with signing or striping. Typical examples include bridges with narrow widths and sections of roadway that cannot be widened without removing significant street trees. These conditions preferably should not exist for more than a quarter of a mile, or on high speed highways. "Zebra" warning striping should be installed to shift traffic away from the obstacle and allow for a protected buffer for bicycle travel.

In situations where a specific obstacle such as a bridge abutment cannot be avoided, a pavement marking consisting of a single six inch white line starting 20 feet before and offset from the obstacle can also be used to alert cyclists that the travel lane width will soon narrow ahead. (See Section 1003.6 of the Caltrans Highway Design Manual for specific instructions.)

In either situation, where bicycle traffic is anticipated, a “SHARE THE ROAD” sign should be used to supplement the warning striping. On longer sections of roadway that are irrevocably narrow, edge striping should be employed to narrow the travel lane and apportion pavement space for a partial shoulder. In situations where even these measures may not provide adequate roadway space for cyclists, it is recommended that an alternate route be designated.

11.2.6 Pavement Design

Though wider tires are now very common and bicycle suspension systems are becoming increasingly prevalent, bicycles still require a riding surface without significant obstacles or pavement defects because they are much more susceptible to such surface irregularities than are motor vehicles. Asphalt is preferred over concrete where shoulders are employed. The outside pavement area where bicycles normally operate should be free of longitudinal seams. Where transverse expansion joints are necessary on concrete, they should be saw cut to ensure a smooth transition. In areas where asphalt shoulders are added to existing pavement, or where pavement is widened, pavement should be saw cut to produce a tight longitudinal joint to minimize wear and expansion of the joint.

11.2.7 Raised Roadway Markers

Raised roadway markers such as reflectors or rumble strips should not be used on roadway edges where bicycles are most likely to operate because they are a surface irregularity that can be hazardous to bicycle stability. Painted stripes or flexible reflective tabs are preferred. In no case should strips of raised reflectors that are intended to warn motorists to reduce vehicle speeds prior to intersections be allowed to cross through the bicycle travel lane.

11.2.8 Utilities

Because bicycles are much more sensitive to pavement irregularities than motor vehicles, utility covers should be adjusted as a normal function of any pavement resurfacing or construction operations. Failure to do so can result in the utility cover being sunken below the paving surface level which creates a hazard experienced cyclists refer to as “black holes.” Also, it is common practice to excavate trenches for new utilities at road edges, the same location as bicycle facilities. When such trenching is completed, care should be given to replacing the full surface of the bicycle lane from the road edge to the vehicle travel lane instead of narrow strips that tend to settle or bubble, causing longitudinal obstructions. Replacement of the bike lane striping should also be required.

11.2.9 Drainage Facilities

Storm water drainage facilities and structures are usually located along the edge of roadways where they often present conflicts with cyclists. Careful consideration should be given to the location and design of drainage facilities on roadways with bicycle facilities.

All drainage grate inlets pose some hazard to bicycle traffic. The greatest hazard comes from stream flow drainage grates which can trap the front wheel of a bicycle and cause the cyclist to lose steering control, or have the narrow bicycle wheels drop into the grate. A lesser hazard is caused by cyclists swerving into the lane of traffic to avoid any type of grate or cover. Riding across any wet metal surface increases the chances of a sudden slip fall.

Only a “bicycle safe” drainage grate with acceptable hydraulic characteristics should be used. The inlet grate should be used in all normal applications and should be installed flush with the final pavement. Where additional drainage inlet capacity is required because of excessive gutter flow or grade (greater than two percent), double inlets should be considered. Depressed grates and stream flow grates should not be used except in unique or unusual situations that require their use and only outside the lane sharing area. Where necessary, depressed grates should only be installed on shoulders six feet wide or greater. Where projects offer the possibility for replacement of stream flow grates located in the lane sharing area, these grates should be replaced with the “bicycle safe” grate.

When roads or intersections are widened, new bicycle safe drainage grates should be installed at a proper location at the outside of the roadway, existing grates and inlet boxes should be removed and the roadway reconstructed. Drainage grate extensions, the installation of steel or iron cover plates or other “quick fix” methods which allow for the retention of the subsurface drain inlet are unacceptable measures since they will create a safety hazard in the portion of the roadway where cyclists operate.

Manholes and covers should be located outside of the lane sharing area wherever possible. Utility fixtures located within the lane sharing area, or any travel lane used by bicycle traffic, should be relocated. Where these fixtures cannot be avoided, the utility fixture cover should be made flush with the pavement surface.

11.2.10 Combination Curb and Gutter

These types of curbs reduce space available for cyclists. The width of the gutter pan should not be used when calculating the width of pavement necessary for shared use by cyclist. On steep grades, the gutter should be set back an additional one foot to allow space to avoid high speed crashes caused by the longitudinal joint between the gutter pan and pavement. Where the combination curb and gutter is used, pavement width should be calculated by adding one foot from the curbed gutter.

11.2.11 Bridges

Bridges provide essential crossings over obstacles such as rivers, rail lines and high speed roadways, but they have been almost universally constructed for the expedience of motor vehicle traffic and often have features that are not desirable for bicycling. Among these features are widths that are narrower than the approach roadways (especially when combined with relatively steep approach grades), low railings or parapets, high curbs and expansion joints that can cause steering problems.

Though sidewalks are generally not recommended for cycling, there are limited situations such as long or narrow bridges where designation of the sidewalk as an alternate bikeway facility can be beneficial to cycling, especially when compared to riding in the narrow bridge roadway. This is only recommended where the appropriate curb cuts, ramps and signage can also be included. Using the bridge sidewalk as a bikeway facility is especially useful where pedestrian use is expected to be minimal. Appropriate signage directed to all potential users should be installed so that they will be aware of the shared use situation. Bridge railings or barrier curb parapets where bicycle use is anticipated should be a minimum of 4.5 feet high.

Short of wholesale replacement of existing narrow bridges over rail lines and highways, there are a few measures to substantially improve safety for cyclists. Signage warning motorists of both the presence of cyclists and the minimal bridge width should be installed at the bridge approaches. “Zebra” warning stripe areas should be painted along high curbs to deter cyclists from riding too close to them, which can result in the pedal hitting these high, curbs, causing a crash. This situation is of particular concern since the cyclist will want to stay as far to the right as possible to avoid passing motor vehicles traffic, even though riding far to the right increases the chances of hitting the high curb.

Though the first alternative mentioned above, bridge replacement, is the preferred alternative for bridges that are too narrow, it is the least likely to occur due to cost. A second alternative is to direct cyclists to alternate, safer routes, but this will not always be practical since highway and rail crossing points are usually limited in number and considerable distances apart. In any case, these other crossing points may well have similar width restrictions.

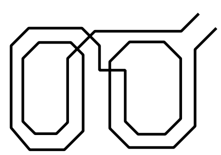
A third alternative is to build separate bridges for cyclist and pedestrian use. Where access warrants a workable solution, this could be a cost-effective long-term solution compared to rebuilding the motor vehicle bridge. These additional bridges could be built adjacent to the motor vehicle bridges, or be installed well away from them, depending upon where best to conveniently accommodate cyclists and pedestrians, who would also undoubtedly use such facilities. An advantage to constructing the bridges away from the motor vehicle bridges is that only one bridge would be needed since building bicycle/pedestrian bridges immediately adjacent to existing motor vehicle bridges would require constructing two one-way spans, one on each side of the roadway, for optimum user safety.

If sidewalk widths are sufficient, directing cyclists to use the sidewalks and installing ramps at the bridge ends is a possible solution. In general, sidewalks are not recommended as a cycling venue and riding on sidewalks is illegal, but in cases where narrow bridges are not expected to be rebuilt for an extended period of time, this may be a reasonable alternative. If possible, a railing should be installed between the roadway and the sidewalk.

Finally, it should be noted that all the other alternatives are inherently inferior to the first alternative of rebuilding narrow bridges in terms of safety, and should only be considered where the first alternative cannot be implemented.

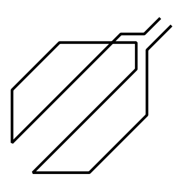
11.2.12 Traffic Control Devices

As legitimate users of California's roadways, cyclists are subject to essentially the same rights and responsibilities as motorists. In order for cyclists to properly obey traffic control devices, those devices must be selected and installed to take their needs into account. All traffic control devices should be placed so cyclists who are properly positioned on the road can observe them. This includes programmed visibility signal heads.



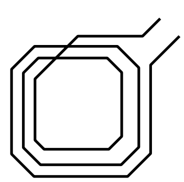
Quadrupole Loop

Detects most strongly in center
Sharp cut-off of sensitivity
Used in bike lanes



Diagonal Quadrupole Loop

Sensitive over whole area
Sharp cut-off of sensitivity
Used in shared lanes



Standard Loop

Detects most strongly over wires
Gradual cut-off
Used for advanced detection

Source: City of San Diego

Traffic Signals and Detectors

Traffic-actuated signals should accommodate bicycle traffic. Detectors for traffic-activated signals should be sensitive to bicycles, should be located in the cyclist's expected path and stenciling should direct the cyclist to the point where the bicycle will be detected. Examples of successful bicycle-sensitive signal detector installation and their specific applications are shown below.

Since detectors can fail, added redundancy in the event of failure is recommended in the form of pedestrian push buttons at all signalized intersections. These buttons should be mounted in a location that permits their activation by a cyclist without having to dismount.

It is increasingly common for bicycles to be made of so little ferrous metals that they may not be detectable by many currently installed types of loop detectors. Of the types available, those illustrated at right should be used.

Where left turn lanes are provided and only protected left turns are allowed, bicycle sensitive loop detectors should be installed in the left turn lane, or a pedestrian style push button should be provided that is accessible to the cyclist in the median immediately adjacent to the turn lane to permit activation of the left turn phase. Where moderate or heavy volumes of bicycle traffic exist, or are anticipated, bicycles should be considered in the timing of the traffic signal cycle as well as in the selection and placement of the traffic detector device. In such cases, short clearance intervals should not be used where cyclists must cross multi-lane streets. According to the 1991 AASHTO Guide for the Development of Bicycle Facilities, a bicycle speed of 10 m.p.h. and a perception/reaction time of 2.5 seconds can be used to check the clearance interval. Where necessary, such as for particularly wide roadways, an all-red clearance interval can be used.

In general, for the sake of cyclist safety, protected left turns are preferred over unprotected left turns. In addition, traffic signal controlled left turns are much safer for cyclists than left turns at which motorists and cyclists must simply yield. This is because motor vehicle drivers, when approaching an unprotected left turn situation or planning to turn left at a yield sign, tend to watch for other motor vehicles and may not see an approaching cyclist. More positive control of left turns gives cyclists an added margin of safety where they need it most.

Signing

When designating a bicycle route, the placement and spacing of signs should be based on the Caltrans Traffic Manual and Highway Design Manual. For bike route signs to be functional, supplemental plaques can be placed beneath them when located along routes leading to high demand destinations (e.g. “To Downtown,” “To Transit Center,” etc.) Since bicycle route continuity is important, directional changes should be signed with appropriate arrow subplaques. Signing should not end at a barrier. Instead, information directing the cyclist around the barrier should be provided.

According to the Manual on Uniform Traffic Control Devices (MUTCD) Part 2A-6: “Care should be taken not to install too many signs. A conservative use of regulatory and warning signs is recommended as these signs, if used to excess, tend to lose their effectiveness. On the other hand, a frequent display of route markers and directional signs to keep the driver informed of his location and his course will not lessen their value.”

“BIKE ROUTE” - This sign is intended for use where no unique designation of routes is desired. However, when used alone, this sign conveys very little information. It can be used in connection with supplemental plaques giving destinations and distances. (See Section 1003-3 of the Caltrans Highway Design Manual and Part 9B-22 of the MUTCD for specific information on subplaque options.)

Roadways that are appropriate for bicycle use, but are undesignated, usually do not require regulatory, guide or informational signing in excess of what is normally required for motorists. In certain situations, however, additional signing may be needed to advise both motorists and cyclists of the shared use of the roadway, including the travel lane.

"SHARE THE ROAD" - This sign is recommended where the following roadway conditions occur:

• Shared lanes (especially if lane widths do not comply with Table 11-1) with relatively high posted travel speeds of 40 m.p.h. or greater;

• Shared lanes (conforming with Table 11-1) in areas of limited sight distance;

• Situations where shared lanes or demarcated shoulders or marked bike lanes are dropped or end and bicycle and motor vehicle traffic must begin to share the travel lane;

• Steep descending grades where bicycle traffic may be operating at higher speeds and requires additional maneuvering room to shy away from pavement edge conditions;

• Steep ascending grades, especially where there is no paved shoulder, or the shared lane is not adequately wide and bicycle traffic may require additional maneuvering room to maintain balance at slow operating speeds;

• High volume urban conditions, especially those with travel lanes less than the recommended width for lane sharing;

• Other situations where it is determined to be advisable to alert motorists of the likely presence of bicycle traffic and to alert all traffic of the need to share available roadway space.

11.2.13 Intersections and Driveways

High speed, wide radius intersection designs with free rights turns, multiple right turn lanes, and wide radius turns increase traffic throughput for motor vehicles by minimizing speed differentials between entering and exiting vehicles and through vehicles. However, these designs are dangerous for cyclists (and pedestrians) by design since they exacerbate speed differential problems faced by cyclists traveling along the right side of a roadway and encourage drivers to fail to yield the right-of-way to cyclists. As a result, Caltrans District 11 (San Diego County area) no longer allows such wide radius free right turns at interchanges.

Where they already exist, specific measures should be employed to ensure that the movement of cyclists along the roadway will be visible to motorists and to provide cyclists with a safe area to operate to the left of these wide radius right turn lanes. One method to accomplish this is to stripe (dash) a bicycle lane throughout the intersection area. Also, "SHARE THE ROAD" signs should be posted in advance of the intersection to alert existing traffic. In general, however, curb radii should be limited to short distances, which helps to communicate to the motorist that he or she must yield the right-of-way to cyclists traveling and pedestrians walking along the sidewalk or roadway margin approaching the intersection.

Even so, wherever possible, such intersection conditions should be eliminated. Reconstruction of intersections to accomplish this is a legitimate use of bicycle program funds.

Sand, gravel and other debris in the cyclist's path present potential hazards. In order to minimize the possibility of debris from being drawn onto the pavement surface from unpaved intersecting streets and driveways, during new construction, reconstruction and resurfacing, all unimproved intersecting streets and driveways should be paved back to the right-of-way line or a distance of 10 feet. Where curb cuts permit access to roadways from abutting unpaved parking lots, a paved apron should be paved back to the right-of-way line, preferably 10 feet from the curb line. These practices will lessen the need for maintenance debris removal. The placement of the paved back area or apron should be the responsibility of those requesting permits for access via curb cuts from driveways and parking lots onto the roadway system.

11.2.14 Roadside Obstacles

To make certain that as much of the paved surface as possible is usable by bicycle traffic, obstructions such sign posts, light standards, utility poles and other similar appurtenances should be set back a one foot minimum “shy distance” from the curb or pavement edge with exceptions for guard rail placement in certain instances. Additional separation distance to lateral obstructions is desirable. Where there is currently insufficient width of paved surface to accommodate bicycle traffic, any placement of equipment should be set back far enough to allow room for future projects (widening, resurfacing) to bring the pavement width into conformance with these guidelines. Vertical clearance to obstructions should be a minimum of 8 feet, 6 inches. (See Section 1003.1 of the Caltrans Highway Design Manual.)

11.2.15 Railroad Crossings

As with other surface irregularities, railroad grade crossings are a potential hazard to bicycle traffic. To minimize this hazard, railroad grade crossings should, ideally, be at a right angle to the rails. This minimizes the possibility of a cyclist’s wheels being trapped in the rail flangeway, causing loss of control. Where this is not feasible, the shoulder (or wide outside lane) should be widened, or “bumped out” to permit cyclists to cross at right angles. (See Section 1003.6 of the Caltrans Highway Design Manual.)

It is important that the railroad grade crossing be as smooth as possible and that pavement surfaces adjacent to the rail be at the same elevation as the rail. Pavement should be maintained so that ridge buildup does not occur next to the rails.

Options to provide a smooth grade crossing include removal of abandoned tracks, use of compressible flangeway fillers, timber plank crossings or rubber grade crossing systems. These improvements should be included in any project, which offers the opportunity to do so.

11.2.16 TSM Type Improvements

Transportation Systems Management (TSM) improvements are minor roadway improvements which enhance motor vehicle flow and capacity. They include intersection improvements, channelization, addition of auxiliary lanes, turning lanes and climbing lanes. TSM improvements must consider the needs of bicycle traffic in their design, or they may seriously degrade the ability of the roadway to safely accommodate cyclists. The inclusion of wider travel lanes or adjacent bike lanes will decrease traffic conflicts and increase vehicular flow. Designs should provide for bicycle compatible lanes or paved shoulders. Generally, this requires that the outside through lane and (if provided) turning lane be 14 feet wide. Auxiliary or climbing lanes should conform to Table 11-1 by either providing an adjacent paved shoulder, or a shared lane width of at least 15 feet. Where shared lanes and shoulders are not provided, it must be assumed that bicycle traffic will take the lane.

11.2.17 Marginal Improvements and Retrofitting Existing Roadways

There may be instances or locations where it is not feasible to fully implement guidelines pertaining to the provision of adequate pavement space for shared use due to environmental constraints or unavoidable obstacles. In such cases, warning signs and/or pavement striping must be employed to alert cyclists and motorists of the obstruction, alert motorists and cyclist of the need to share available pavement space, identify alternate routes (if they exist), or otherwise mitigate the obstruction.

On stretches of roadway where it is not possible to provide recommended shoulder or lane widths to accommodate shared use, bicycle traffic conditions can be improved by:

• Striping wider outside lanes and narrower interior lanes; or

• Providing a limited paved shoulder area by striping a narrow travel lane. This tends to slow motor vehicle operating speeds and establish a space (with attendant psychological benefits) for bicycle operation.

Where narrow bridges create a constriction, “zebra“ striping should be used to shift traffic away from the parapet and provide space for bicycle traffic.

Other possible strategies include:

• Elimination of parking or restricting it to one side of the roadway;

• Reduction of travel lanes from two in each direction to one in each direction plus center turn lane and shoulders; or

• Reduction of the number of travel lanes in each direction and the inclusion or establishment of paved shoulders.

11.2.18 Access Control

Frequent access driveways, especially commercial access driveways, tend to convert the right lane of a roadway and its shoulder area into an extended auxiliary acceleration and deceleration lane. Frequent turning movements, merging movements and vehicle occupancy of the shoulder can severely limit the ability of cyclists to utilize the roadway and are the primary causes of motor vehicle-bicycle collisions. As a result, access control measures should be employed to minimize the number of entrances and exits onto roadways. For driveways having a wide curb radius, consideration should be given to marking a bicycle lane through the driveway intersection areas. As with other types of street intersections, driveways should be designed with sufficiently tight curb radii to clearly communicate to motorists that they must fully stop and then yield the right-of-way to cyclists and pedestrians on the roadway.

11.2.19 Bikeway Reconstruction after Construction

Since roadways with designated bicycle facilities carry the largest volumes of users, their reconstruction should be of particular concern. Unfortunately, bicycle facilities are often installed piecemeal and users can find themselves facing construction detours and poor integration of facilities where the facilities begin and end.

Bicycles facilities also sometimes seem to “disappear” after roadway construction occurs. This can happen incrementally as paving repairs are made over time and are not followed by proper bikeway restriping. When combined with poor surface reconstruction following long periods out of service due to road work, this can result in the eventual loss of affected bikeway facilities and decrease the number of cyclists regularly using bicycle facilities within the City of Chula Vista.

Adjacent construction projects that require the demolition and rebuilding of roadway surfaces can cause problems in maintaining and restoring bikeway function. Construction activities controlled through the issuance of permits, especially driveway, drainage, utility, or street opening permits, can have an important effect on the quality of a roadway surface where cyclists operate. Such construction can create hazards such as mismatched pavement heights, rough surfaces or longitudinal gaps in adjoining pavements, or other pavement irregularities.

Permit conditions should ensure that pavement foundation and surface treatments are restored to their preconstruction conditions, that no vertical irregularities will result and that no longitudinal cracks will develop. Stricter specifications, standards and inspections designed to prevent these problems should be developed, as well as more effective control of construction activities wherever bikeways must be temporarily demolished. A five-year bond should be held to assure correction of any deterioration, which might occur as a result of faulty reconstruction of the roadway surface.

Spot widening associated with new access driveways frequently results in the relocation of drainage grates. Any such relocation should be designed to close permanently the old drainage structure and restore the roadway surface. New drainage structures should be selected and located to comply with drainage provisions established in these guidelines.

11.2.20 Maintenance Priorities

Bikeway maintenance is easily overlooked. The “sweeping” effect of passing motor vehicle traffic readily pushes debris toward the roadway edges where it can accumulate within an adjoining bicycle facility. Litter and broken glass usually ends up in these areas as well. Since the potential for loss of control can exist due to a blowout caused by broken glass, or through swerving to avoid other debris, proper maintenance is directly related to safety. For this reason, street sweeping must be a priority on roadways with bike facilities, especially in the curb lanes and along the curbs themselves. The police department could assist by requiring towing companies to fully clean up crash scene debris, or face a fine. This would prevent glass and debris from being left in place after a motor vehicle crash, or simply swept into the curb or shoulder area.

Suggested minimum sweeping schedule:

• Class 1:	heavy use	monthly
	light use	twice/year
• Class 2:	heavy use	monthly
• Class 3:		twice/year

The availability of a forum through which citizens can conveniently notify the proper city authority of bikeway facility problems or shortcomings is desirable. The City of San Diego Street Division, for example, makes available a Service Request form via the city’s Internet home page to allow citizens to report problems relating to streets, sidewalks, drains and other civil engineering infrastructural issues. It does not specifically mention bicycle facilities in its list of selected problems, but does offer the user the opportunity to type in the particulars of any street-related issue.

11.2.21 Intermodal Planning and Facilities

Creating an environment conducive to intermodal transit begins with providing the proper types of facilities and amenities in locations convenient enough to attract potential users. Such facilities can include those described in the following sections.

Bike Lockers and Racks

The provision of bicycle racks and lockers is an important first step in making a multi-modal system work for cyclists. Their presence encourages cyclists to use available transit because these facilities help to alleviate concerns about security, primarily theft or vandalism of bicycles parked for long periods.

Additional Bus-mounted Racks
The provision of bus-mounted bicycle racks on more bus routes may encourage cyclists to use the bus system, especially in the eastern sections of the City where topography is the most pronounced. These racks should be mounted on the front of the bus to increase visibility between the bus driver and the cyclist using the rack and to decrease the chance of theft while the bus is stopped.

11.2.22 Traffic Calming

There exist roadway conditions in practically all communities where controlling traffic movements and reducing motor vehicle speeds is a worthwhile way to create a safer and less stressful environment for the benefit of non-motorized users such as pedestrians and cyclists. These controlling measures are referred to as traffic calming. These measures are also intended to mitigate impacts of vehicular traffic such as noise, crashes and air pollution, but the primary link between traffic calming and bicycle planning is the relationship between motor vehicle speed and the severity of crashes. European studies have shown that instituting traffic calming techniques significantly decreases the number of pedestrian and cyclist fatalities in crashes involving motor vehicles, as well as the level of injuries and air pollution, without decreasing traffic volume.

Stop Signs/Yield Signs
The installation of stop signs is a common traffic calming device intended to discourage vehicular through traffic by making the route slower for motorists. However, stop signs are not speed control devices, but rather right-of-way control devices. They do not slow the moving speed of motor vehicles and compliance by cyclists is very low. Requiring motor vehicles to stop excessively also contributes to air pollution. Cyclists are even more inconvenienced by stop signs than motorists because unnecessary stopping requires them to repeatedly reestablish forward momentum. The use of stop signs as a traffic management tool is not generally recommended unless a bicycle route must intersect streets with high motor vehicle traffic volumes. Controlled intersections generally facilitate bicycle use and improve safety and stop signs tend to facilitate bicycle movement across streets with heavy motor vehicular traffic. An alternative to stop signs may be to use yield signs or other traffic calming devices as methods to increase motorist awareness of crossing cyclists.

Speed Bumps and Tables
Though many cities are no longer installing speed bumps, they have been shown to slow motor vehicle traffic speeds and reduce volume. If speed bumps are employed as a traffic management tool, a sufficiently wide gap must be provided to allow unimpeded bicycle travel around the bump to prevent safety hazards for cyclists. Standard advance warning signs and markers must be installed as well.

Partial Traffic Diverters
These traffic calming devices include traffic circles and chicanes, both of which force traffic to follow a curved path, which had formerly been straight. They are usually employed in areas of traditional grid street configuration. These devices can actually increase traffic hazards if they are not substantial enough to decrease motor vehicle speeds, or if appropriate side street access points are not controlled.

Total Traffic Diverters
These diverters close roadways to motor vehicles only, or divert them to other routes while continuing to provide access to non-motorized users. Partial diverters allow access for cyclists in both directions, but block motor vehicle entry at one end. Both devices reduce motor vehicle driver options as a means to

reduce the local traffic volume while allowing unrestricted access for pedestrians and cyclists. They are only useful where bicycles are fully exempt from the restrictions preventing the access of motor vehicles. Bicycle access should be clearly signed where motor vehicle access is limited so that cyclists are made aware that they can proceed even though motor vehicles cannot.

Curb Extensions and Radius Reductions
Larger curb radii are intended to facilitate high speed right-turn movements for the convenience of motorists. However, these larger radii are more dangerous for crossing and adjacent cyclists and pedestrians both because of the resulting higher motor vehicle speeds and the longer crossing distance for the cyclists and pedestrians. Motorists tend to spend less time looking for pedestrians and cyclists when they are attempting to make a high speed turn because their attention is focused on watching for oncoming traffic from the left. Their tendency to watch for pedestrians crossing from the right is also reduced. In addition, this type of intersection encourages higher speed movements across the bicycle travel lane, increasing the risk of collisions. To avoid these problems, curb radii should be reduced and curb extensions installed that pinch in toward the motor vehicle traffic lanes. This narrowing of the roadway tends to reduce traffic speeds, which creates a longer period for drivers to see potential conflicts before making right turns. However, due to the resulting reductions in motor vehicle speeds, this approach may not be appropriate at congested intersections. In such cases, there should instead be a safe lane and crossover segment especially for cyclists.

Extensions are curb bulbs extending into the intersection from the corners of one or both of the intersecting roadways. Reducing curb radii functionally narrows the intersection, shortening the crossing distance for pedestrians and cyclists and slowing approaching traffic. Curb extensions are even more effective than reduced curb radii in decreasing crossing distance and slowing traffic. They can also serve the additional purposes of defining parking lanes and improving visibility at corners.

The use of curb extensions should be confined to residential areas and commercial zones with moderate posted speed limits since they prevent the use of the curb lane for cycling in favor of vehicular parking. Reduced curb radii can be used more widely, or on streets with routine large truck use requiring right turns.

11.3 Class 1 Multi-Use Trail Guidelines

Class 1 facilities are generally paved multi-use paths or trails, separated from motor vehicle traffic. Off street routes are rarely constructed for the exclusive use of cyclists since other non-motorized user types will also find such facilities attractive. For that reason, the facilities recommended in this master plan should be considered multi-use where cyclists will share the pathways with other users. The recommended Class 1 routes (bike paths) are intended to provide commuting and recreational routes through areas not served by roadways.

No matter what their primary focus, most cyclists will find bicycle paths inviting routes to ride, especially if travel efficiency is secondary to enjoyment of cycling. Since these paths can augment the existing roadway system, they can extend circulation options for cyclists, making trips feasible which would not otherwise be possible if the cyclists had to depend exclusively on roadways, especially in areas where usable roads are limited. Class B and C (casual and children) cyclists would likely also appreciate the relative freedom from conflicts with motor vehicles compared to riding on typical roadways.

By law, the presence of a Class 1 route near an existing roadway does not justify prohibiting bicycles on the parallel or nearly parallel roadway. Where a bikeway master plan calls for Class 1 routes parallel to the alignments of planned roadways, these roadways should still be designed to be compatible with bicycle use. (According to the City policy, most new roadways east of I-805 are planned to include Class 2 bike lanes.) Two reasons to retain parallel facilities are that an experienced cyclist may find Class 1 paths inappropriate because of intensive use, or the routes may not be direct enough to suit the experienced cyclist. By the same token, the Class 1 path will likely be much more attractive to less experienced cyclists than a parallel facility on the street.

In general, Class 1 facilities should not be placed immediately adjacent to roadways. Where such conditions exist, Class 1 facilities should be offset from the street as much as possible and separated from it by a physical barrier. These measures are intended to promote safety for both the cyclists and the motorists by preventing unintended movement between the street and the Class 1 facility.

11.3.1 Class 1 Planning Issues

Shared Use of Multiple Use Paths

Since off-street paths (Class 1) are now generally regarded as multi-use and not for the exclusive use of cyclists, they must be designed for the safety of both cyclists and other expected user types. Heavy use of multi-use trails can create conflicts between different types of users. These conflicts can include speed differentials between inexperienced and experienced cyclists as well as between pedestrians, joggers and in-line skaters, differences in the movements typical of particular user types and even the kinds of groupings common to the different user types as they casually move down the pathway.

As long as volumes are low, the level of conflict between different user types can be managed without enforcement. However, even moderate increases in user volume can create substantial deterioration in level of service and safety. Conflicts between different user types are especially likely to occur on regionally significant recreational trails that attract a broad diversity of users, (such as the Bayshore Bikeway). In general, paths that are expected to receive heavy use should be a minimum of 14 feet wide, paths expected to experience moderate use should be at least 12 feet wide and low volume paths can be 10 feet wide. Caltrans Class 1 requirements call for eight feet (2.4 meters) as the minimum width with two-foot (0.6 meters) clear areas on each side.

Regulation of Multiple Use Paths

The potential for multiple-use path conflicts has increased substantially in recent years with the increased popularity of jogging, mountain bikes and in-line skating. Where multi-use trails were once commonly used primarily by pedestrians and secondarily by cyclists, today they tend to be used by a roughly equal distribution of pedestrians, cyclists and in-line skaters.

In-line skating has been the fastest growing sport in America for several years. Also, the majority of bicycles sold in the United States over the last decade have been mountain bikes, far outstripping sales of drop-bar type road bike sales. The mountain bike's relative comfort and upright riding position have helped to encourage inexperienced cyclists who previously rarely rode to do so more often.

Methods used to reduce trail conflicts have included providing separate facilities for different groups, prohibiting certain user types, restricting certain uses to specific hours, widening existing facilities or marking lanes to regulate traffic flow. Examples of all of these types of actions occur along the coastal trails of southern California where conflicts between different user types can be especially severe during peak periods.

Compatibility of Multiple Use of Paths or Trails

Joint use of paths by cyclists and equestrians can pose problems due to the ease with which horses can be startled. Also, the requirements of a Class 1 bikeway facility include a solid surface, which is not desirable for horses. Therefore, where either equestrian or cycling activity is expected to be high, separate trails are recommended. On facilities where Class 1 designation is not needed and the facility will be unpaved, mountain bikes and horses can share the trail if adequate passing width is provided, the expected volume of traffic by both groups is low and available sight distances allow equestrians and cyclists to anticipate and prepare for possible conflicts. Education of all trail users in “trail etiquette” has proven to be helpful on shared trails elsewhere.

The recent surge in the popularity of mountain bikes has increased conflicts on narrow trails with minimal surface improvements that were originally designed for hiking alone. On some trails, especially ones that are contiguous over distances greater than the average hiker’s typical one-day hiking range, mountain bikes now commonly outnumber hikers.

The primary problem with this mixed use is the speed differential between mountain bikers and hikers. This difference is exacerbated by additional concerns such as limited sight distances due to topography and vegetation. Like other uses, mountain bikes can also cause some erosion or compaction problems. Once again, education is an important component in minimizing conflicts. This includes situations where adjacent vegetation or habitat is considered sensitive. Because cyclists are probably the most likely to remain on the path, signs restricting users to the trail may be sufficient, though the addition of fencing or railings may be required if signage does not achieve the desired results.

Urban Access Pathways

Conflicts between different user types on multiple use routes occur primarily on heavily used recreational paths, or near major pedestrian trip generators. Lightly used neighborhood pathways and community trails can be safely shared by a variety of user types. Construction of urban access pathways between adjoining residential developments, schools, neighborhoods and surrounding streets can substantially expand the circulation opportunities for both pedestrians and cyclists.

However, bicycle use of urban access pathways should not include sidewalks adjacent to streets for a number of reasons. First, sidewalks are designed for pedestrian speeds and maneuverability. Second, they are usually encumbered by parking meters, utility poles, benches, trees, etc. Third, other types of users and their specific types of maneuverability can also pose a safety issue for cyclists.

Though sidewalks are, in general, not conducive to safe cycling, an exception is Class C cyclists, young children. This type of bicycle use is generally acceptable because it provides young children who do not yet have the judgment or skill to ride in the street an opportunity to develop their riding skills. Sidewalks in residential areas generally have low pedestrian volumes and are usually accepted as play areas for children.

Finally, one other exception to sidewalk use by cyclists should be allowed. This is where the walkway is at least eight feet wide and well away from streets, such as within parks. In such cases, bicycle use on walkways can occur safely.

Bicycle Paths Adjacent to Roadways
Two-way bicycle facilities located immediately adjacent to a roadway are not recommended because they require one direction of bicycle traffic to ride against motor vehicle traffic, contrary to the normal "Rules of the Road." This puts the wrong way cyclists in the motorists' "blind spot" at intersections where they do not have the right-of-way, or are not noticed by motorists turning right because the cyclists are not on the roadway. Many cyclists will also find it less convenient to ride on this type of facility as compared to streets, especially for utility trips such as commuting. This more experienced group of cyclists may find the roadway more efficient, safer, or better maintained than the adjacent bicycle facility. The AASHTO guide says that: "...bicycle lanes, or shared roadways should generally be used to accommodate bicycle traffic along highway corridors rather than providing a bicycle path immediately adjacent to the highway."

An exception to this general rule can occur where an off-road route intended primarily for bicycle use must be located adjacent to a roadway for a short distance to maintain trail continuity such as when an existing roadway's bridge will be used by the trail. Even so, physical separation of the bikeway facility from the roadway must be provided.

11.4 Design of Class 1 Facilities (Paths Primarily Used by Bicycles)

A substantial portion of the following sections is taken directly from the *AASHTO Guide for the Development of Bicycle Facilities*, 1991. Note that AASHTO's use of the term "bicycle path" is equivalent to a "Class 1 bicycle facility" as defined by Caltrans and as used in this master plan. Also, the AASHTO term "highway" is synonymous with the term "roadway." Finally, all measurements in the Caltrans documents are now in metric form.

11.4.1 Width and Clearance
The paved width and the operating width required for a bicycle path are primary design considerations. Under most conditions, recommended paved width for a two-directional bicycle path is 10 feet. In some instances, however, a minimum of eight feet can be adequate. This minimum should be used only where the following conditions prevail: (1) bicycle traffic is expected to be low, even on peak days or during peak hours; (2) pedestrian use of the facility is not expected to be more than occasional; (3) there will be good horizontal and vertical alignment providing safe and frequent passing opportunities; and (4) the path will not be subject to maintenance vehicle loading conditions that would cause pavement edge damage. Under certain conditions it may be necessary or desirable to increase the width of bicycle path to 12 feet or more, for example, because of substantial bicycle volume, probable shared use with joggers and other pedestrians, use by large maintenance vehicles, steep grades, or where bicycles will be likely to ride two abreast.

Reduced widths are acceptable on access pathways due to their generally short length and low volumes. However, wherever possible, minimum width standards should be employed. One-directional bicycle facilities are not generally recommended since they will almost certainly be used as two-way facilities.

A minimum of 2 feet width graded area should be maintained adjacent to both sides of the pavement. However, 3 feet or more is desirable to provide clearance from trees, poles, walls, fences, guardrails, or other lateral guidelines. A wider graded area on either side of the bicycle path can serve as a separate jogging path. The vertical clearance to obstructions should be a minimum of 8 feet.

However, vertical clearance may need to be greater to permit passage of maintenance vehicles and, in undercrossings and tunnels, a clearance of 10 feet is desirable for adequate vertical shy distance.

11.4.2 Horizontal Separation from Roadways

Class 1 bicycle facilities are generally physically separated from roadways. However, where a Class 1 facility must be considered within a roadway right-of-way, a wide separation between a bicycle path and adjacent highway is desirable to confirm for both the cyclist and the motorist that the bicycle path functions as an independent highway for bicycle traffic. In addition to physical separation, landscaping or other visual buffer is desirable. When this is not possible and the distance between the edge of the roadway and the bicycle path is less than 5 feet, a suitable physical divider may be considered. Such dividers serve both to prevent cyclists from making unwanted movements between the path and the highway shoulder for the protection of cyclists from motor vehicles and to reinforce the concept that the bicycle path is an independent facility. Where used, the divider should be a minimum of 4.5 feet high to prevent cyclists from toppling over it and it should be designed so that it does not become an obstruction or traffic hazard in itself.

11.4.3 Design Speed

A cyclist's speed is dependent on several factors, including the type and condition of the bicycle, the purpose of the trip, the condition and location of the bicycle path, the speed and direction of the wind and the physical condition of the cyclist. Bicycle paths should be designed for a selected speed that is at least as high as the preferred speed of the faster cyclists. In general, a minimum design speed of 20 m.p.h. should be used. However, when the grade exceeds four percent, a design speed of 30 m.p.h. is advisable.

On unpaved paths, where cyclists tend to ride slower, a lower design speed of 15 m.p.h. can be used. Similarly, where the grades dictate, a higher design speed of 25 m.p.h. can be used. Since bicycles have a higher tendency to skid on unpaved surfaces, horizontal curvature design should take into account lower coefficients of friction.

11.4.4 Horizontal Alignment and Superelevation

The minimum radius of curvature negotiable by a bicycle is a function of the superelevation rate of the bicycle path surface, the coefficient of friction between the bicycle tires and the bicycle path surface and the speed of the bicycle. The minimum design radius of curvature can be derived from the following formula:

$$R = \frac{V^2}{127\left(\frac{e}{100} + f\right)}$$

R = Minimum radius of curvature (meters)
V= Design speed (k.p.h.)
e = Rate of superelevation
f = Coefficient of friction

For most bicycle path applications, the superelevation rate will vary from a minimum of two percent (the minimum necessary to encourage adequate drainage) to a maximum of approximately five percent (beyond which maneuvering difficulties by slow bicycles and adult tricyclists might be expected). The minimum superelevation rate of two percent will be adequate for most conditions and will simplify construction.

The coefficient of friction depends upon speed; surface type, roughness and condition; tire type and condition; and whether the surface is wet or dry. Friction factors used for design should be selected based upon the point at which centrifugal force causes the cyclist to recognize a feeling of discomfort and instinctively act to avoid higher speed. Extrapolating from values used in highway design, design factors for paved bicycle paths can be assumed to vary from 0.30 at 15 m.p.h. to 0.22 at 30 m.p.h.. (Based on a superelevation rate (e) of two percent, minimum radii of curvature can be selected from Figure 1003.1C of the Caltrans Highway Design Manual.)

When substandard radius curves must be used on bicycle paths because of right-of-way, topography, or other considerations, standard curve warning signs and supplemental pavement markings should be installed in accordance with the Caltrans Highway Design Manual. The negative effects of substandard curves can also be partially offset by widening the pavement through the curves.

11.4.5 Grade

Grades on bicycle paths should be kept to a minimum, especially on long inclines. Grades greater than five percent are undesirable because the ascents are difficult for many cyclists and the descents cause some cyclists to exceed the speeds at which they are competent. Where terrain dictates, grades over five percent and less than 500 feet long are acceptable when a higher design speed is used and additional width is provided.

11.4.6 Switchbacks

In areas of steep terrain, a series of "switchbacks" may be the only solution to traversing changes in elevation. At these locations, a grade of eight percent is acceptable for a distance of no more than 100 feet. Where applicable, grades steeper than eight percent will not meet Americans with Disabilities Act (ADA) standards. Switchback radii should be larger than normally employed for pedestrian facilities to allow for cyclists to be able to safely make the turns without having to dismount. Pavement width should be a minimum of 12 feet wide to allow ascending cyclists room to walk their bicycles when necessary. The switchbacks should be completely visible from the next uphill turn. Runouts at the end of each turn should be considered for cyclists unable to slow down quickly enough to make the turn. Railings should be installed to discourage shortcuts and appropriate signing should be placed at the top of the descent.

11.4.7 Sight Distances

To provide cyclists with an opportunity to see and react to the unexpected, a bicycle path should be designed with adequate stopping sight distance. The distance required to bring a bicycle to a full controlled stop is a function of the cyclist's perception and brake reaction time, the initial speed of the bicycle, the coefficient of friction between the tires and the pavement and the braking ability of the bicycle. Figure 1003.1D of the Caltrans Highway Design Manual indicates the minimum stopping sight distance for various design speeds and grades based on a coefficient of 0.25 to account for the poor wet weather braking characteristics of many bicycles. For two-way bicycle paths, the sight distance in descending direction, that is, where "G" is negative, will control the design.

11.4.8 Intersections

Intersections with roadways are important considerations in bicycle path design. If alternate locations for a bicycle path are available, the one with the most favorable intersection conditions should be selected. For crossings of freeways and other high-speed, high-volume arterials, a grade separation structure may be the only possible or practical treatment. Unless bicycles are prohibited from the crossing highway, providing for turning movements must be considered. When intersections occur at grade, a major consideration is the establishment of right-of-way. The type of traffic control to be used (signal, stop sign, yield sign, etc.) and locations should be provided in accordance with the Caltrans Traffic Manual.

Sign type, size and location should also be in accordance with the Caltrans Traffic Manual. Care should be taken to ensure that bicycle path signs are located so that motorists are not confused by them and that roadway signs are placed so that they do not confuse cyclists. Other means of alerting cyclists of a highway crossing include lateral deflections or small vertical deflections, as well as changing the paving surface at the approach. Devices installed to prohibit motorists from entering the bike path can also assist with alerting cyclists to crossings, but they must be well marked, including with reflective markings.

It is preferable that the crossing of a bicycle path and a highway be at a location away from the influence of intersections with other highways. Controlling vehicle movements at such intersections is more easily and safely accomplished through the application of standard traffic control devices and normal Rules of the Road. Where physical constraints prohibit such independent intersections, the crossings may be at or adjacent to the pedestrian crossing. Right of way should be assigned and sight distance should be provided so as to minimize the potential for conflict resulting from unconventional turning movements. At crossings of high volume multi-lane arterial highways where signals are not warranted, consideration should be given to providing a median refuge area for cyclists.

The entrances to Class 1 paths can sometimes create crossing conflicts. Methods to resolve this include signalized striped crosswalks with pedestrian push-buttons, bicycle loop detectors and pavement logos, bicycle signal heads, in-pavement flashing lights at unsignalized intersections, and various traffic calming techniques. Bollards should also be placed at the entrance to the path to keep vehicles from entering.

When bicycle paths terminate at existing roads, it is important to integrate the path into the existing system of roadways. Care should be taken to properly design the terminals to transition the traffic into a safe merging or diverging situation. Appropriate signing is necessary to warn and direct both cyclists and motorists regarding these transition areas.

Bicycle path intersections and approaches should be on relatively flat grades. Stopping sight distances at intersections should be checked and adequate warning should be given to permit cyclists to stop before reaching the intersection, especially on downgrades.

Ramps for curb cuts at intersections should be the same width as the bicycle paths. Curb cuts and ramps should provide a smooth transition between the bicycle paths and the roadway.

11.4.9 Signing and Marking

Adequate signing and marking are essential on bicycle paths, especially to alert cyclists to potential conflicts and to convey regulatory messages to both cyclists and motorists at highway intersections. In addition, guide signing, such as to indicate directions, destinations, distance, route numbers and names of crossing streets, should be used in the same manner as they are used on highways. In general, uniform application of traffic control devices, as described in the Caltrans Highway Design and Traffic Manuals, will tend to encourage proper cyclist behavior.

A designer should consider a 4 inch wide yellow centerline stripe to separate opposite directions of travel if heavy volumes of bicycles are expected, on curves with restricted sight distances; and on unlighted paths where nighttime riding is expected. Edge lines can also be very beneficial where significant nighttime bicycle traffic is expected.

General guidance on signing and marking is provided in the Caltrans *Highway Design Manual*. Care should be exercised in the choice of pavement marking materials. Some marking materials are slippery when wet and should be avoided in favor of more skid-resistant materials.

11.4.10 Pavement Structure

Under most circumstances, a two-inch thick asphalt top course placed on a six-inch thick select granular subbase is suitable for a bikeway pavement structure. Where unsatisfactory soils can be anticipated, a soil investigation should be conducted to determine the load-carrying capabilities of the native soil and the need for any special provisions.

In addition, some basic differences between the operating characteristics of bicycles and those of motor vehicles should be recognized. While loads on bicycle paths will be substantially less that typical roadway loads, paths should be designed to sustain without damage the wheel loads of occasional emergency, patrol, maintenance and other motor vehicles that are expected to use or cross the path. Where such motor vehicle use will be required, four inches of asphalt should be used. Additional pavement structure may also be necessary in flood plains and in locations where shallow root systems may heave thin pavement sections.

Special consideration should be given to the location of motor vehicle wheel loads on the path. When motor vehicles are driven on bicycle paths, their wheels will usually be at or very near the edges of the path. Since this can cause edge damage that, in turn, will result in the lowering of the effective operating width of the path, adequate edge support should be provided. Edge support can be either in the form of stabilized shoulders or in constructing additional pavement width. Constructing a typical pavement width of 12 feet, where right-of-way and other conditions permit, eliminates the edge raveling problem and offers two other additional advantages over shoulder construction. First, it allows additional maneuvering space for cyclists and second, the additional construction cost can be less than that for constructing shoulders because the separate construction operation is eliminated.

It is important to construct and maintain a smooth riding surface on bicycle paths. Bicycle path pavements should be machine laid. Root barriers should be used where necessary to prevent vegetation from rupturing the pavement over time, and on Portland cement concrete pavements, transverse joints, necessary to control cracking, should be saw cut to provide a smooth ride. On the other hand, skid resistance qualities should not be sacrificed for the sake of smoothness. Broom finish or burlap drag concrete surfaces are preferred over trowel finishes, for example.

At unpaved highway or driveway crossings of bicycle paths, the highway or driveway should be paved a minimum of 10 feet on each side of the crossing to reduce the amount of gravel being scattered along the path by motor vehicles. The pavement structure at the crossing should be adequate to sustain the expected loading at the location.

11.4.11 Structures

An overpass, underpass, small bridge, drainage facility or facility on a highway bridge may be necessary to provide continuity to a bicycle path. On new structures, the minimum clear width should be the same as the approach paved bicycle path and the desirable clear width should include the minimum two-foot wide clear areas. Carrying the clear areas across the structures has two advantages. First, it provides a minimum horizontal shy distance from the railing or barrier, and second, it provides needed maneuvering space to avoid conflicts with pedestrians and other cyclists who are stopped on the bridge. Access by emergency, patrol and maintenance vehicles should be considered in establishing the design clearances of structures on bicycle paths. Similarly, vertical clearance may be dictated by occasional motor vehicles using the path. Where practical, a vertical clearance of 10 feet is desirable for adequate vertical shy distance.

Railings, fences, or barriers on both sides of a bicycle path structure should be a minimum of 4.5 feet high. Smooth rub rails should be attached to the barriers at handlebar height of 3.5 feet.

Bridges designed exclusively for bicycle traffic may be designed for pedestrian live loading. On all bridge decks, special care should be taken to ensure that bicycle safe expansion joints are used.

Where it is necessary to retrofit a bicycle path onto an existing highway bridge, several alternatives should be considered in light of what the geometrics of the bridge will allow.

One option is to carry the bicycle path across the bridge on one side. This should be done where the bridge facility will connect to a bicycle path at both ends, sufficient width exists on that side of the bridge, or can be obtained by widening or restriping lanes; and provisions are made to physically separate bicycle traffic from motor vehicle traffic as discussed above.

A second option is to provide either wide curb lanes or bicycle lanes over the bridge. This may be advisable where the bicycle path transitions into bicycle lanes at one end of the bridge; and sufficient width exists, or can be obtained by widening or restriping.

A third option is to use existing sidewalks as one-way or two-way facilities. This may be advisable where conflicts between cyclists and pedestrians will not exceed tolerable limits, and the existing sidewalks are adequately wide. Under certain conditions, the cyclist may be required to dismount and cross the structure as a pedestrian.

Because of the large number of variables involved in retrofitting bicycle facilities onto existing bridges, compromises in desirable design criteria are often inevitable. Therefore, the width to be provided is best determined by the designer, on a case-by-case basis, after thoroughly considering all the variables.

11.4.12 Drainage

The recommended minimum pavement cross slope of two percent adequately provides for drainage. Sloping in one direction instead of crowning is preferred and usually simplifies the drainage and surface construction. A smooth surface is essential to prevent water ponding and ice formation.

Where a bicycle path is constructed on the side of a hill, a ditch of suitable dimensions should be placed on the uphill side to intercept the hillside drainage. Such ditches should be designed in such a way that no undue obstacles are presented to cyclists. Where necessary, catch basins with drains should be provided to carry the intercepted water under the path. Drainage grates and manhole covers should be located outside of the travel path of the cyclist. (See Section 1003.6 of the Caltrans *Highway Design Manual*.) To assist in draining the area adjacent to the bicycle path, the design should include considerations for preserving the natural ground cover. Seeding, mulching and sodding of adjacent slopes, swales and other erosion prone areas should be included in the design plans.

11.4.13 Lighting

Lighting is encouraged for both guidance and safety reasons and should be considered along Class 1 paths especially if heavy use is expected in the evening hours. Applicable situations include bicycle paths serving colleges or employment centers, as well as at highway intersections. Lighting should also be considered through underpasses or tunnels and when nighttime security could be a problem. Fixed-source lighting reduces conflicts along the paths and at intersections. In addition, lighting allows the cyclist to see the bicycle path direction, surface conditions and obstacles.

Depending on the location, average maintained horizontal illumination levels of 5 to 22 lux should be considered. Light standards (poles) should meet the recommended horizontal and vertical clearances. Luminaires and standards should be at a scale appropriate for a pedestrian or bicycle path. (See Section 1003.6 of the Caltrans *Highway Design Manual*.)

11.4.14 Barriers to Motor Vehicle Traffic

Bicycle paths often need some type of physical barrier at highway intersections and pedestrian-load bridges to prevent unauthorized motor vehicles from using the facilities. Provisions can be made for a lockable, removable post to permit entrance by authorized vehicles. The post should be permanently reflectorized for nighttime visibility and painted a bright color for improved daytime visibility. When more than one post is used, a five foot spacing is desirable. Wider spacing can allow entry to motor vehicles, while narrower spacing might prevent entry by adult tricycles and bicycles with trailers. Striping an envelope around the barrier is recommended. (See Section 1003.1 of the Caltrans *Highway Design Manual*.)

An alternate method of restricting entry of motor vehicles is to split the entryway into two five-foot sections separated by low landscaping. Emergency vehicles can still enter if necessary by straddling the landscape. The maintenance costs associated with landscaping should be acknowledged, however, before this alternative method is selected.

11.5 Unpaved Multi-Use Facilities

In some cases, unpaved trails or roads may be used as part of a bikeway system. Though not eligible for official designation as bicycle facilities, they can be acknowledged as “informal” unpaved connections between official paved segments. Because these routes are generally in less developed areas, they may also be considered scenic unpaved “byways” that can be accessed via the official bikeway system.

Most of the bicycles sold today are mountain bikes designed for use on unpaved surfaces and come equipped with wide tires and low gearing. Many recreational cyclists ride this type of bicycle and may use them on a well maintained unpaved route. Unpaved routes are unlikely to attract many commuting cyclists, but the routes may experience some utility use if they provide convenient shortcuts between popular destinations where such routes would not otherwise exist.

Available guidelines for unpaved facilities are limited. In general, the coefficient of friction used in calculating curve radii and a factor in determining design speed, should be reduced. Although there are not data available for unpaved surfaces, it is suggested that friction factors be reduced by 50 percent to allow a sufficient margin of safety. This reduction in friction affects all situations where traction is important, especially on grades. Grades steeper than three percent may not be practical for bicycle paths with crushed stone surfaces.

In cases where switchbacks are necessary for unpaved paths that occur in steep terrain, curve radii may be enlarged, the path widened and runout areas provided. In areas of erosive soils, it is also advisable to install signage requiring cyclists to dismount when traversing the switchbacks.

11.6 Class 2 Facilities

Class 2 facilities are marked bicycle lanes within roadways usually adjacent to the curb lane, delineated by appropriate striping and signage.

Bicycle lanes can be considered when it is desirable to delineate available road space for preferential use by cyclists and motorists and to provide for more predictable movements by each. Bicycle lane markings can increase a cyclist's confidence in motorists not straying into his/her path of travel. Likewise, passing motorists are less likely to swerve to the left out of their lane to avoid cyclists on their right.

Bicycle lanes should always be one-way facilities and carry traffic in the same direction as adjacent motor vehicle traffic. Two-way bicycle lanes on one side of the roadway are unacceptable because they promote riding against the flow of motor vehicle traffic. Wrong-way riding is the primary cause of bicycle crashes and violates the "Rules of the Road" stated in the Uniform Vehicle Code. Bicycle lanes on one-way streets should be on the right side of the street, except in areas where a bicycle lane on the left will decrease the number of conflicts (e.g., those caused by heavy bus traffic). In unique situations, it may be appropriate to provide a contra-flow bicycle lane on the left side of a one-way street. Where this occurs, the lane should be marked with a solid, double yellow line and the width of the lane should be increased by one foot.

11.6.1 Lane Widths

Under ideal conditions, the minimum bicycle lane width is five feet. However, certain edge conditions dictate additional desirable bicycle lane width. Figure 1003.2A of the Caltrans *Highway Design Manual* depicts four common locations for such facilities in relation to the roadway. The first figure depicts bicycle lanes on an urban curbed street where a striped parking lane is provided. The minimum bicycle lane width for this location is five feet. If parking volume is substantial or turnover is high, an additional one or two feet of width is desirable for safe bicycle operation. Bicycle lanes should always be placed between the parking lane and the motor vehicle lanes. Bicycle lanes between the curb and the parking lane can create obstacles for cyclists and eliminate a cyclist's ability to avoid a car door as it is opened. Therefore, this placement should not be considered.

The second figure depicts an urban curbed street where parking is allowed, but without striping for a separate bike lane. This parking lane shared with bicycles should be 11 to 12 feet wide. 13 feet is recommended where parking turnover is high, such as commercial districts. Cyclists do not generally ride near a curb because of the possibility of debris, of hitting a pedal on the curb, of an uneven longitudinal joint, or of a steeper cross slope.

The third figure shows a roadway where parking is prohibited. Bicycle lanes in this location should have a minimum width of five feet where a curb occurs (measured from the curb face) and four feet where no curb is used. If the longitudinal joint between the gutter pan and the roadway surface is uneven and falls within five feet of the curb face, a minimum of four feet should be provided between the joint and the motor vehicle lanes.

The fourth figure depicts bicycle lanes on a roadway where parking is prohibited and without curbs. Bicycle lanes should be located between the motor vehicle lanes and the roadway shoulders. In this situation, bicycle lanes may have a minimum width of four feet, since the shoulder can provide additional maneuvering width. A width of five feet or greater is preferable. Additional widths are desirable where substantial truck traffic is present, or where vehicle speeds exceed 40 m.p.h. In certain situations, it may be appropriate to designate the full shoulder as the bike lane.

11.6.2 Intersections

Bicycle lanes tend to complicate both bicycle and motor vehicle turning movements at intersections. Because they encourage cyclists to keep to the right and motorists to keep to the left, both operators are somewhat discouraged from merging in advance of turns. Thus, some cyclists will begin left turns from the right side of the bicycle lane and some motorists will begin right turns from the left side of the bicycle lane. Both maneuvers are contrary to established Rules of the Road and result in conflicts.

Design treatment for bicycle lanes at a simple intersection is shown in Figure 1003.2B of the Caltrans *Highway Design Manual*. On a two lane roadway, the edge line along the bike lane should end approximately 200 feet from the intersection to allow left turning cyclists and right turning motorists to “weave.”

Design treatment at multi-lane intersections is more complex. Figure 1003.2C of the Caltrans *Highway Design Manual* presents examples of pavement markings for bicycle lanes approaching motorist right-turn-only lanes. Where there are numerous left turning cyclists, a separate turning lane should be considered.

The design of bicycle lanes should also include appropriate signing at intersections to reduce the number of conflicts. General guidance for pavement marking of bicycle lanes is contained in Section 1003.2 of the Caltrans *Highway Design Manual*. (See the Caltrans *Traffic Manual* for more specific information.)

Adequate pavement surface, bicycle-safe grate inlets, safe railroad crossings and traffic signals responsive to bicycles should always be provided on roadways where bicycle lanes are being designated. Raised pavement markings and raised barriers can cause steering difficulties for cyclists and should not be used to delineate bicycle lanes.

11.6.3 Signing and Striping Requirements

Signing and striping should be in accordance with Section 1004 of the Caltrans *Highway Design Manual* and the *Caltrans Traffic Manual*. Bicycle lanes should be well marked and signed to ensure clear understanding of the presence and purpose of the facility by both cyclists and motorists. The Caltrans *Traffic Manual* also specifies standard signing for bicycle lanes. The appropriate signs should be used in advance of the beginning of a marked designated bicycle lane to call attention to the lane and to the possible presence of cyclists. Signs should be used only in conjunction with the appropriate pavement marking and erected at periodic intervals along the designated bicycle lane and in the vicinity of locations where the preferential lane symbol is used.

Where it is necessary to restrict parking, standing, or stopping in a designated bicycle lane, appropriate signs, as described in the Caltrans *Traffic Manual*, may be used. For example, the City of Carlsbad uses a combination “NO PARKING/BIKE LANE” sign, especially along the beach area where frequent stopping is a problem.

Bicycle lane stripes should be solid, six to eight inch wide white lines. Care should be taken to use pavement striping that is skid-resistant. Thermoplastic tape and painted markings can become slippery and cause the cyclist to fall. Impregnated grit, nonskid, preformed tape is an acceptable striping material.

It is very important to reapply bicycle lane markings when they begin to fade, since faded bicycle lane markings can lead to confusion for motorists and cyclists. If necessary, reapplication of bicycle lane stripes should be placed on a more frequent schedule than regular roadway restriping projects. Old markings should be removed prior to restriping if new layers of marking materials would otherwise create raised areas that would be hazardous to cyclists.

Prompt replacement of bicycle lane striping following pavement repairs should be the responsibility of the paving contractor for projects that have required the removal and replacement of bike lane paving. Too often, lane striping is not replaced following construction or repaving projects.

Preferential bicycle lane symbols should be installed on the pavement in bicycle lanes. Symbols should be installed at regular intervals (no more that 350 feet between symbols), immediately after intersections and at areas where bicycle lanes begin. Pavement letters that spell “BIKE ONLY,” and arrows are optional, but desirable.

11.7 Class 3 Facilities

A Class 3 facility is a suggested bicycle route that usually consists of a series of signs designating a preferred route between destinations such as residential and shopping areas. A network of such routes can provide access to a number of destinations throughout the community. In some cases, looped systems of scenic routes have been created to provide users with a series of recreational experiences. In addition, such routes can provide relatively safe connections for commuting to workplaces or schools.

The designation of a roadway as a Class 3 facility should be based primarily on the advisability of encouraging bicycle use on that particular roadway. While the roadways chosen for bicycle routes may not be free of problems, they should offer the best balance of safety and convenience of the available alternatives. In general, the most important considerations are pavement width and geometrics, traffic conditions and appropriateness of the intended purpose. A certain amount of risk and liability exists for any area that is signed as a Class 3 route. The message to the user public is that the facility is a safe route. Therefore, routes should not be placed on streets that do not meet appropriate safety standards.

Attributes that describe how appropriate a particular road is for a bicycle route include directness, connectivity with other bicycle facilities, scenery and available services. Directness is important for cyclists traveling for a purpose, such as commuting, though this is not the case for recreational riders, for whom scenery may be the primary factor in selecting a route. For recreational riders traveling more than a few miles, services such as food, water, restrooms and pressurized air may be of interest.

According to the January, 2005 issue of the journal *Planning*, a new shared lane pavement marking will soon become a standard in California. It is intended to direct cyclists to ride far enough to the left to avoid car doors while signaling to motorists that the roadway is also a bicycle route. The symbol below is to be placed 11 to 13 feet from the curb face.

11.7.1 Roadway Engineering

While design of all Class 1 and 2 bikeways should follow the Bikeway Planning and Design Chapter 1000 of Caltrans' *Highway Design* and *Traffic Manuals*, there are bound to be situations where the recommended geometrics for a Class 3 facility can not be achieved, such as due to right-of-way constraints, for example. Planning and design of the Class 3 facility should emphasize safety for cyclists and provide additional warnings to motorists to be aware of the presence of cyclists.